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STUDY OF WEAR BEHAVIOR OF SS316LN USING PLASMA NITRIDING

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ABSTRACT

The paper shows the consequences of an examination concerning the wear conduct of nitride 316LN austenitic tempered steel. The main scope of this study is to determine the wear, tensile strength and microstructure evaluation of the SS316LN plasma nitrating samples. The test was conducted where the plasma nitrating process was applied on the sample with different time periods and also compared with and without plasma nitrating sample. Wear test was directed utilizing pin on circle mechanical assembly to portray the conduct of austenitic treated steel. Nitrating is surface-hardening heat treatment that introduces nitrogen into the surface of steel at a temperature range of 500 – 550 C. It requires less time and lower temperature to provide distortion of work piece that carburizing.

KEYWORDS: SS316LN, Plasma Nitrating, Tensile Quality, Wear Test, Microstructure, Hardness & Tempered Steel

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Original Article

INTRODUCTION

Stainless steels area unit trendy materials. Chrome steel is the generic name for variety of various steels used primarily for his or her resistance to corrosion. Chrome steel is not one material; however, the name for a family of corrosion resistance steel in scientific discipline, chrome steel is outlined as a metal alloy with a minimum of 10% Cr content. The name originates from the very fact that chrome steel does not stain, corrode or rust as simply as standard steel. This material is additionally known as corrosion resistant steel once it is not consistent precisely with its alloy kind and grade, notably within the aviation trade. As such, the area unit is currently totally different and simple accessible grades and surface finishes of chrome steel to suit the surroundings of the fabric are subjected to its time period.

Since wear is not a straightforward development, wear resistance is portrayed by fewer standardized tests than different engineering properties. It is usually accepted that a universal wear check is not possible. Therefore, instrumentality for wear testing should be designed to stimulate actual service conditions. These tests ought to have established dependableness ought to be valid by correlation with service knowledge [1 - 4].

It is known that surface hardness of the steels can be increased by the addition of carbon and nascent nitrogen. In carburizing, hardness is increased only by sacrificing the corrosion resistance property of the material. During the carburizing process, the carbon atoms diffuse through the surface and occupy lattice sites of the stainless steel [5 - 8]. These excess carbon atoms have the affinity to react with the chromium present in stainless steel and form chromium carbide, so as explained, the sensitization is not encountered; instead diffusion of nitrogen into surface layers of steel promotes the formation of hard nitrides [9 - 13].

In case of stainless steel, it is expected that the complex hard Fe-Cr nitrides form on the surface, which in turn could improve the surface hardness and wear resistance [14 - 15]. Nitrogen is a very strong austenite stabilizer and stronger promotes austenite structure. Similar advantages of nickel addition/alloying to promote an austenite structure can also be obtained by the case hardening stainless steel by nitrating [16]. It also increases the mechanical strength substantially. Hence, the surface hardening of stainless steel by nitrating is chosen for this study [17 - 20].

The aim of this study is to predict the good wear resistance as well as good tensile strength of the given material. The nitrogen is a strong austenitic stabilizer thereby reducing the amount of nickel required for stabilization. Nitrogen has greater solid-solubility than carbon, thus decreasing the tendency for precipitation at a given level of strengthening. Nitrogen is beneficial for pitting and crevice corrosion resistance. These nitrogen steels possess excellent corrosion resistance and thermal stability.

EXPERIMENTAL PROCEDURES

Plasma Nitrating

In general, plasma nitrating to acquire high surface hardness, increment wear opposition, improves life weakness, improve consumption obstruction and improve a surface that is impervious to the conditioning impact of temperature warmth up to the nitrating temperature.

The plasma procedure is a warm procedure performed in a vacuum situation. The standard preheating cycle extends in temperature from 850 to 1050^{o}F. The procedure gas is ionized by a voltage that is connected to the item. Plasma nitriding is a strategy for surface solidifying utilizing sparkle release innovation to present beginning (basic) nitrogen to the outside of a metal part for consequent dissemination into the material. In a vacuum, high-voltage electrical vitality is utilized to frame plasma through which nitrogen particles are quickened to encroach on the work piece. This particle siege warms the work piece and cleans the surface giving dynamic nitrogen. A key contrast among gas and particle nitriding is the component used to produce nitrogen outside of work.

In the plasma-nitriding process, nitrogen gas (N2) can be utilized rather than smelling salts on the grounds that the gas is separated to frame essential nitrogen affected by the gleam release. In this manner, the nitriding potential can be decisively constrained by the guideline of the N2 content in the process gas.

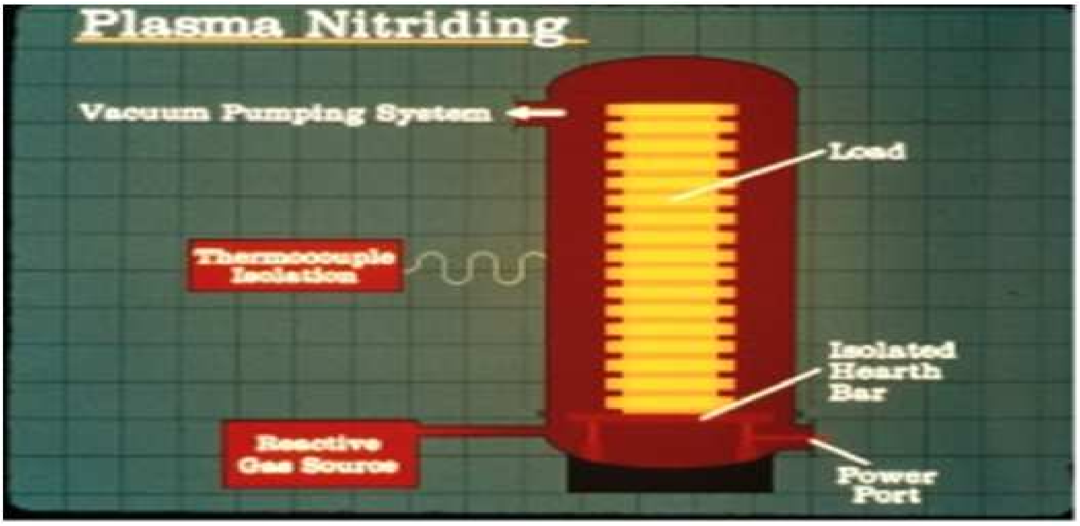

Figure1: Plasma Nitriding Setup.

The plasma nitriding procedure creates a hard external skin on the material being nitride. The hardness accomplished superficially diminishes with profundity until the centre hardness is obtained. Figure 1 demonstrates normal hardness for different combinations at various case profundities. The slant is progressively continuous for low compound steels and sharp for profoundly alloyed steels. The nitride framing components in the steel's synthesis are the essential variables controlling the hardness and the case profundity. The low combination steel will give a more profound case, yet a lower by and large hardness.

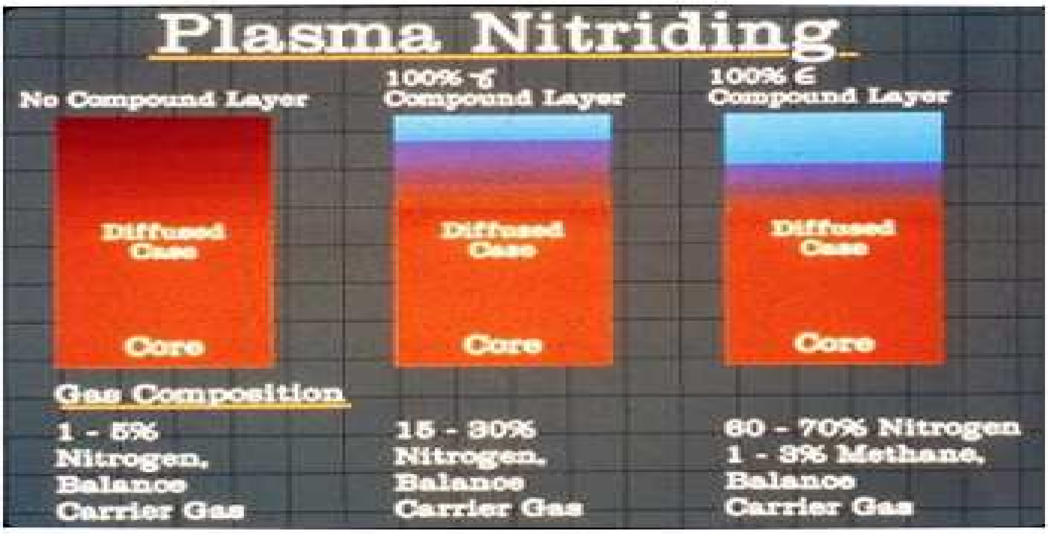

Figure 2: Plasma Nitriding Process.

Figure 2 shows how the metallurgical properties of the nitride layer and the white layer can be controlled in the plasma nitriding process by adjusting the process gas composition.

Plasma nitriding bestows a tough wear safe subtle layer to the surface while not the problems seasoned with most wet shower plating. Because plasma nitriding may be a dissemination procedure, it disposes the problems of break, spalling, edge develop, break and therefore the expense connected with remotion and replating the things, hurt edges, keep sharp throughout plasma nitriding and therefore the uniform shine discharge encompassing all surfaces accomplishes an inevitable hardness and case depth. The development connected with chrome plating that causes the adjusting of edges and webbing at the bottom of cavities is disposed of with plasma nitriding. Currently and once more, granulating is vital to evacuate the intemperate development prompting additional creation prices.

The subtle case in particle nitriding offers nice protection from house that chrome plating does not supply. This allows plasma nitriding to be selected for a lot of in-depth scope of materials and applications. Plasma nitriding can improve the weakness quality of your material. Chrome plating does not supply this advantage. Execution of plasma nitride water-driven shafts in Europe has consummated the conditions for erosion and wear opposition versus chrome. Plasma nitriding is of course friendly. Plasma nitriding does not utilize any dangerous substances. The chrome plating procedure utilizes hexavalent chrome that may be a glorious cancer-causing agent.

Specimen Preparation

The plate type 316 in evaluation tempered steel was cut into little bits of length of 60 mm and width of 10 mm with the assistance of wire-cut EDM procedures circle of 316 in material is utilized, as the plate with 110 mm distance

across and 10 mm thickness. The stick material was nitrided by plasma nitriding and the plate material was surface solidified.

Process Parameters

Investigations were directed on stick plate machine and the accompanying parameters were differed: The heap was conveyed keeping the speed of pivot, sliding separation, sliding speed and the time consistent for one lot of readings. Furthermore, for the other arrangement of readings, time was differed keeping the heap, sliding separation and sliding speed steady. The experimental specimen is shown in figure 3.

Figure 3: Experiment Material.

Specification Wear-Rate Load In 15 kg

Table 1: Wear Rate Parameters.

S No:	Specimen Description	Weight Before Testing (gms)	Weight After Testing (gms)	Weight Loss (gms)	Volume Wear Loss (cm^3)
1.	UNT	18.1280	18.1202	7.8×10^{-3}	9.762×10^{-4}
2.	PN1	18.1012	18.0986	2.6×10^{-3}	5.381×10^{-4}
3.	PN2	18.1427	18.1387	4×10^{-3}	5.006×10^{-4}
4.	PN3	18.4862	18.4819	4.8×10^{-3}	3.254×10^{-4}

Note: Unt- Untreated Specimen
Pn1-Nitrided specimen for 6 hrs (nitrided)
Pn2-Nitrided specimen for 8 hrs (nitrided)
Pn3-Nitrided specimen for 10 hrs (nitrided)

Ultimate Tensile Strength

Extreme rigidity (UTS), frequently abbreviated to physical property (TS) and extreme quality within equations is that the limit of a fabric or structure to resist hundreds having an inclination to stretch, rather than compressive quality, that withstands hundreds having an inclination to decrease live. At the top of the day, rigidity opposes pressure (being force

separated) whereas compressive quality opposes pressure (being pushed together). Extreme rigidity is calculable by the best pressure that a fabric will face up to, whereas being extended or forced before breaking within the investigation of commonness of materials, elasticity, compressive quality and shear quality is examined autonomously.

Figure 4: UTS Sample.

Some materials break terribly sharply, while not plastic deformation, in what is known as a brittle failure. Others, that square measure a lot of ductile, together with most metals, expertise some plastic deformation and presumably necking before fracture. The tensile specimen is shown in figure 4.

The UTS is typically found by performing arts, a tensile check and recording the engineering stress versus strain. The best purpose of the stress–strain curve (see purpose one on the engineering stress–strain diagrams below) is that of the UTS. It is associate degree intensive property; so its price does not depend upon the dimensions of the check specimen. However, it is smitten by different factors, like the preparation of the specimen, the presence or otherwise of surface defects and therefore the temperature of the check atmosphere and material.

RESULTS AND DISCUSSIONS

Wear Behavior

In this work, wear behaviour of 316 LN grade stainless steel was experimented under nitride and normal condition. The major conclusions are as follows:

Experimental Parameters

Load	:	15 kg (constant)
Track diameter	:	13,26,39,52 mm
Diameter of disc	:	110 mm
Height of disc	:	10 mm
Diameter of pin	:	10 mm
Length of pin	:	60 mm

Material of disc	:	Stainless steel
Material of pin	:	Stainless steel
Process used	:	Plasma nitriding
Speed	:	1400 rpm (constant)
Time	:	8 mins(constant)
Density	:	0.08 kg/cm^3

Untreated Specimen

Tim	=	8 min (constant)
Speed	=	1400 rpm (constant)
Load	=	15 kg (constant)
Weight before testing	=	18.1280 gms
Weight after testing	=	18.1202 gms
Weight loss	=	Weight before testing - weight after testing
	=	18.1280 - 18.1202
	=	7.8×10^{-3} gms
Volume of wear loss	=	weight loss/density
	=	0.02040/0.08
	=	9.762×10^{-4} cm^3

PN3 Specimen

Time	=	8 min (constant)
Speed	=	1400 rpm (constant)
Load	=	15 kg (constant)
Weight before testing	=	18.1012 gms
Weight after testing	=	18.0986 gms
Weight loss	=	weight before testing -weight after
Testing	=	18.1012 - 18.0986
	=	2.6×10^{-3} gms
Volume of wear loss	=	Weight loss/density
	=	0.0026/0.08

$= \quad 3.254\times10^{-4}\ cm^3$

Nitriding effectively increase the wear resistance of the material. The wear of the specimen varies with the load applied and the speed of rotation of the disc.

Tension Parameters

Mode of Test	=	tesnion
Sample Type	=	Round
Diameter	=	8.79 mm
Area	=	60.68 mm^2
Gauge Length	=	35.00 mm^2
Final Gauge Length	=	46.080 mm

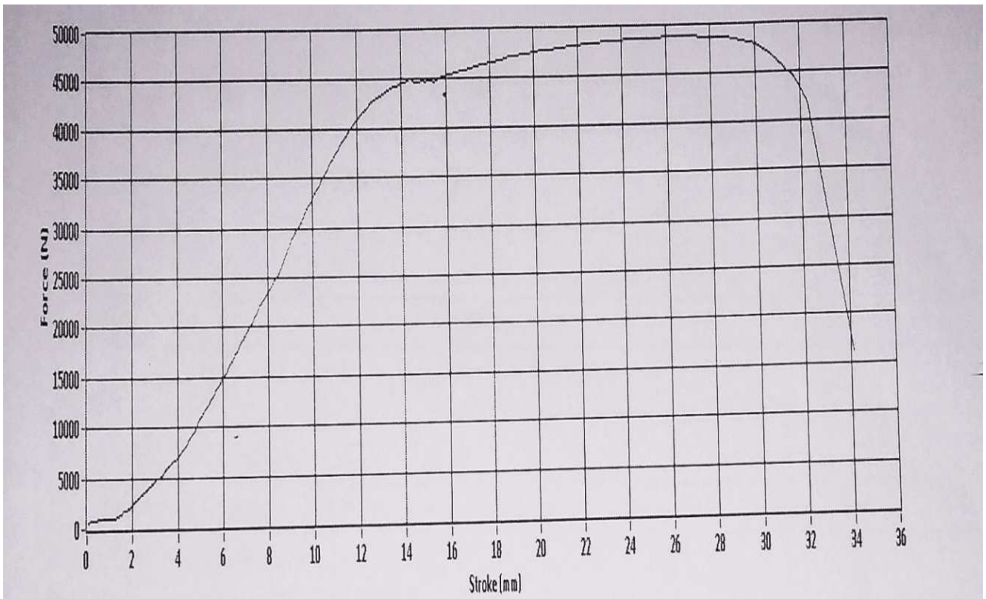

Figure 5: Stress – Strain Curve.

Tensile Strength	806.57 MP a
Yield Stress	733.81 MP a
Elongation	31.66%
Reduction Area	54.95%

The tensile test conducted by under room temperature according to ASTM D 638. The plot is between stress and strain. The above is the sample of Tensile strength of three samples observed by stress - strain curve. The sample 3 is strength is shown in figure 5, among the three samples, the significant sample 3 is high tensile strength (4500 N) obtained.

Microstructure Evaluation

Figure 6 shows plasma nitrating coating on the surface of samples as well as non-coating samples microstructures. This microstructure well revealed the base metal and coating materials.

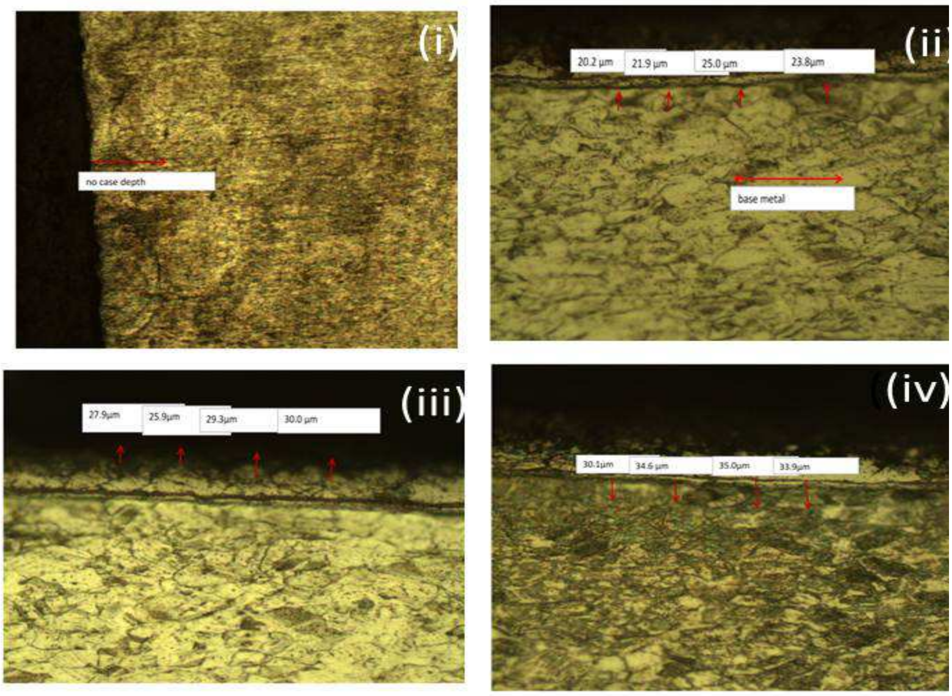

Figure 6: Microstructure of (i) without Coating (UNT) (ii) PN1 (iii) PN2 (iv) PN3 in 6 hrs Soaking Time.

The depth of the plasma nitrogen is well shown in this microstructure. Among the four micrographs, PN3 is good and penetrate through the surface of the samples. Sample three (PN3) has shown nearly 30 µm depth of penetration of plasma nitrating on the surface of samples.

CONCLUSIONS

In this work, wear behaviour of 316 LN grade stainless steel were determined under nitride and normal conditions. The major conclusions are as follows:

- Nitriding effectively increases the wear resistance of the material.
- The wear of the specimen varies with the load applied and the speed of rotation of the disc.
- As the time of nitriding increases from 6 hrs to 10 hrs, case depth increases, wear loss decreases.
- From optical microscope result, PN3 specimen shows maximum case depth.
- As compared to UNT specimen, PN3 has high wear resistance along with increase in durability.
- As compared to UNT and other samples, PN3 has high tensile strength such as 807 MPa attained.

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